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APPLIED REMOTE SENSING PROGRAM (ARSP)

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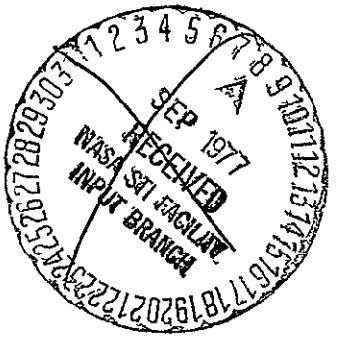
Office of Arid Lands Studies
University of Arizona
Tucson, Arizona 85719

Final report of LANDSAT Investigation #23610

To:

National Aeronautics & Space Administration
Goddard Space Flight Center
Goddard, Maryland 20771



July 1, 1977

In cooperation with

local, regional, state and federal agencies within the State of Arizona

23610

FINAL REPORT

Objectives of Investigation #23610

The objective of LANDSAT investigation #23610 is to establish through joint projects, centers of remote sensing competence and awareness in local and state agencies. To accomplish this objective, various applied remote sensing projects have been initiated with state agencies and/or rural county governments.

As reported in the second quarter report, land use studies have been initiated with four rural Arizona counties (Apache, Yavapai, and Yuma). This progress report gives the final products derived and utility of the information for the Yuma county planning department. The final report will detail the remaining county work.

Methods

During the span of Investigation #23610, the Applied Remote Sensing Program (ARSP) worked cooperatively with the rural Arizona counties of Apache, Graham, Yavapai, and Yuma. The work performed in Yuma county was reported earlier. The jointly funded projects involved the mapping of existing land uses and approximate 100-year floodplains in areas of imminent or ongoing development. In this final report, an explanation of the methods and procedures used in floodplain delineation will procede the resulting uses made by each county.

Interpretive techniques used for all the counties were essentially the same. Initial interpretations of hydrologic parameters, such as geomorphology, vegetation cover, soils, and extent of scour

erosion, were computed by making overlays on the individual bands 4, 5, and 7 obtained from LANDSAT-1. The LANDSAT imagery was used in transparency form at 1:1,000,000 scale. Thirty-six inch (1:250,000) color composite prints of bands 4, 5 and 7 were used as bases for the land use maps.

The next step was the construction of a mosaic using black and white or color infrared high altitude aircraft photography at a contact scale of 1:120,000. The 1:120,000 mosaic was used to further refine the geomorphology, vegetation, soils and erosion interpretations made from the LANDSAT composite.

The topic maps generated for each county are being used by the planning departments in their process of land use regulation. The land use map provides a base from which subdivision development is monitored. The flood hazard map is used by the county planners to direct new development away from areas which are subject to periodic inundation. The map is also needed to comply with state and federal legislation which requires the mapping of flood prone areas for insurance purposes.

COUNTY REPORTS

Graham County

Flooding from the Gila River in the vicinity of Safford, Arizona has occurred periodically since agricultural and urban development began in the early 1900s. In an attempt to delineate flooding potential in areas now devoted primarily to agricultural use but subject to development in the near future, this study has concentrated on the following:

1. Delinate areas subject to inundation along the Gila River between Solomon and Pima by photointerpretive techniques (Clark and Altenstadter, 1974).

2. Compare inundated areas mapped from NASA high altitude photography and LANDSAT to existing U.S.G.S. flood prone area maps.

3. Produce maps of potential flood areas at 1:62,500 for subsequent board adoption as the county's floodplain management program.

Additional input in the form of historic flood data from verbal and newspaper sources, and from known high water marks, was incorporated into the analysis. This procedure was found to be unreliable as precipitation records and stream flow gauge records were inadequate. The lack of recorded data forced reliance upon the memory of area residents as to the height and reoccurrence of flood waters. This technique was not used in the other county projects.

Figures 1, 2 and 3 show the type of information produced in the study. The figures allow decision makers to compare existing land use to flood potential when decisions concerning new development on vacant land were taken under advisement by the Board of Supervisors.

The need in Graham County was not only for flood and erosion hazard delineations to meet state legislative requirements but also for additional evidence toward settlement of a disputed inundation area boundary. The boundary which was provided for Federal Flood Insurance purposes was, according to county officials and to local history, an underestimation of the actual area subject to considerable flooding. Remote sensing-derived flood hazard mapping has enabled the county to appeal the erroneous delineation at minimal cost when compared to standard engineering procedures.

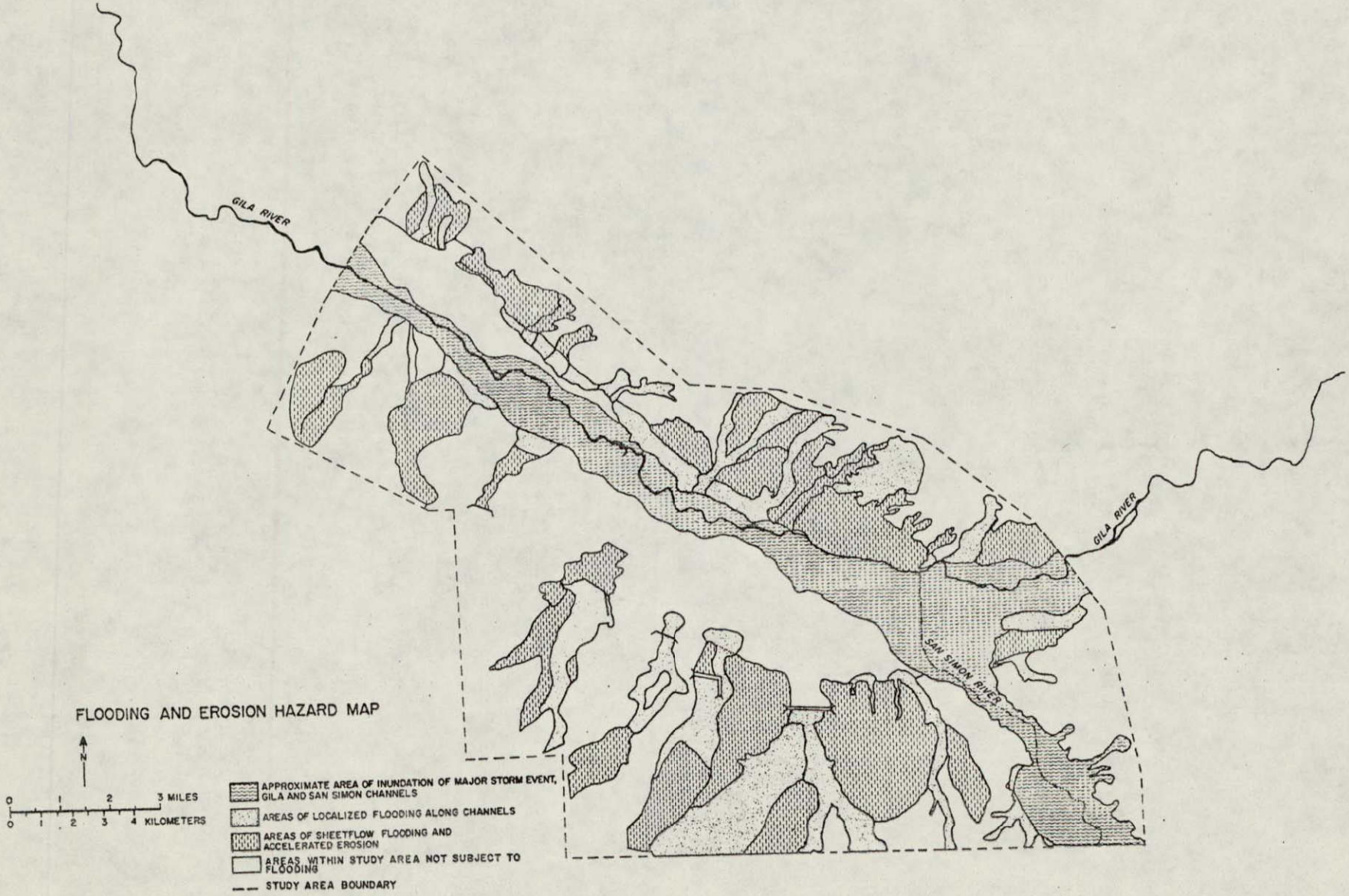


Figure 1. Graham County Flooding and Erosion Hazard Map

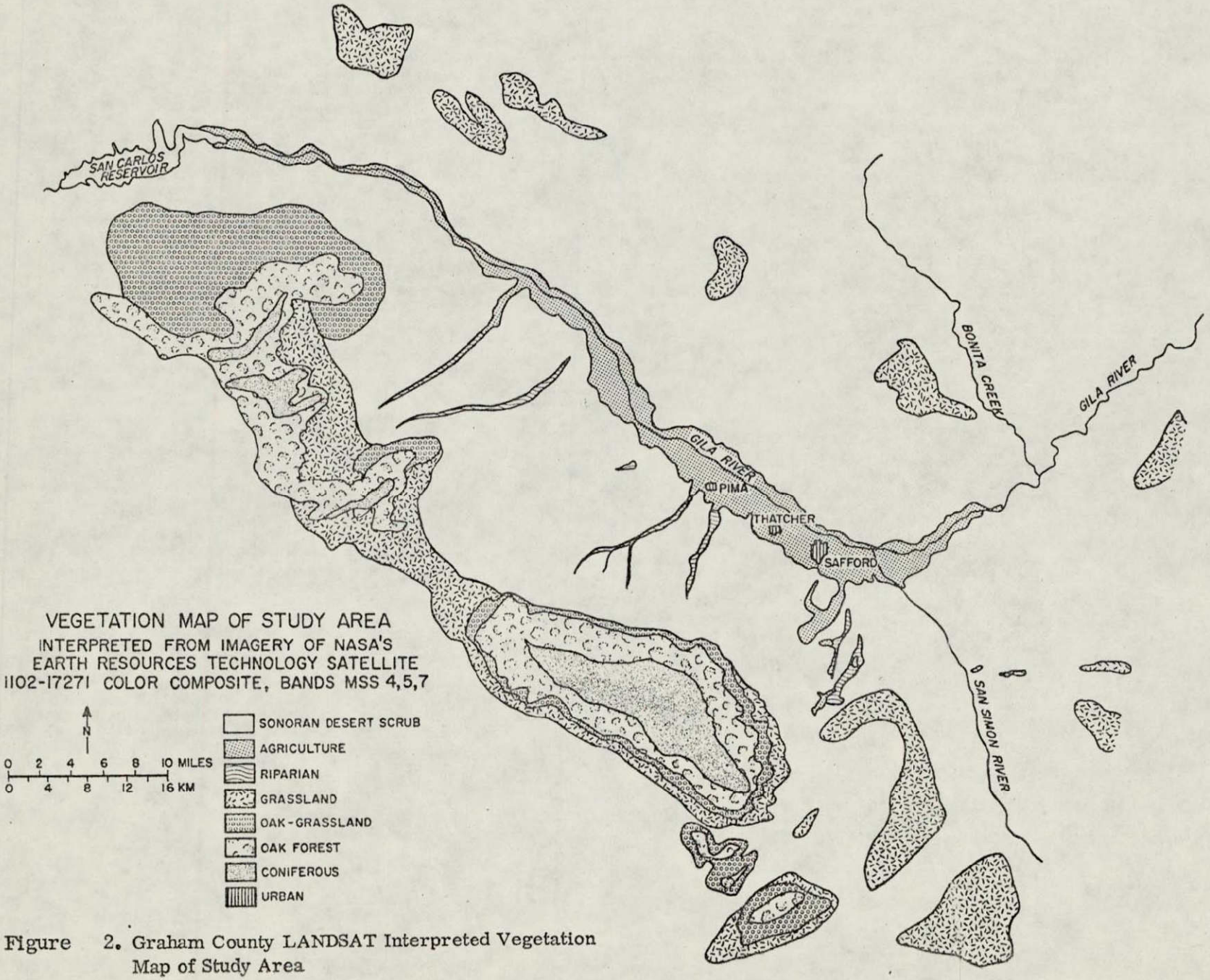


Figure 2. Graham County LANDSAT Interpreted Vegetation Map of Study Area

Figure 3. Graham County High-Altitude Aircraft Interpreted Vegetation Map of Study Area.

Yavapai County

Imagery from LANDSAT-1 and high altitude natural color photographs were interpreted to develop land use (Figure 4) and flood hazard maps (Figure 5) for this central Arizona county. A county-wide land use map was made from 1972 and '73 Arizona Land Use Experiment photography, using black and white prints at 1:120,000 scale. Changes in agricultural and rangeland use patterns were interpreted from enlarged (1:250,000) LANDSAT color composites, and used to update the data derived from the U-2 flights, which were two-to-three years old.

The area selected for flood hazard analysis was the rapidly developing region sourrounding Camp Verde and Cottonwood along the Verde River, Wet Beaver Creek, and West Clear Creek drainages. This area is under pressure of speculative land subdivision, and has a history of severe flooding on the major channels and ephemeral streams. Some subdivided land in the study lies within the main channel of Wet Beaver Creek.

Natural color 9-inch transparencies acquired from RB-57 Mission 155 was utilized as the data base. Overlays were made on the transparencies to delinate stream channels, over flow areas adjacent to channels, areas of sheet flow or surface scour, and areas apparently unaffected by flooding and accelerated erosion. All interpretations were field-checked and modified as necessary.

The watershed of West Clear Creek, which is under very intensive subdivision pressures, was selected for a more intensive land use and floodplain study. Many structures in these subdivision lie within the floodplain of West Clear Creek and may be susceptible to flood damage. Forest Service imagery at 1:31,600 was used for this project.

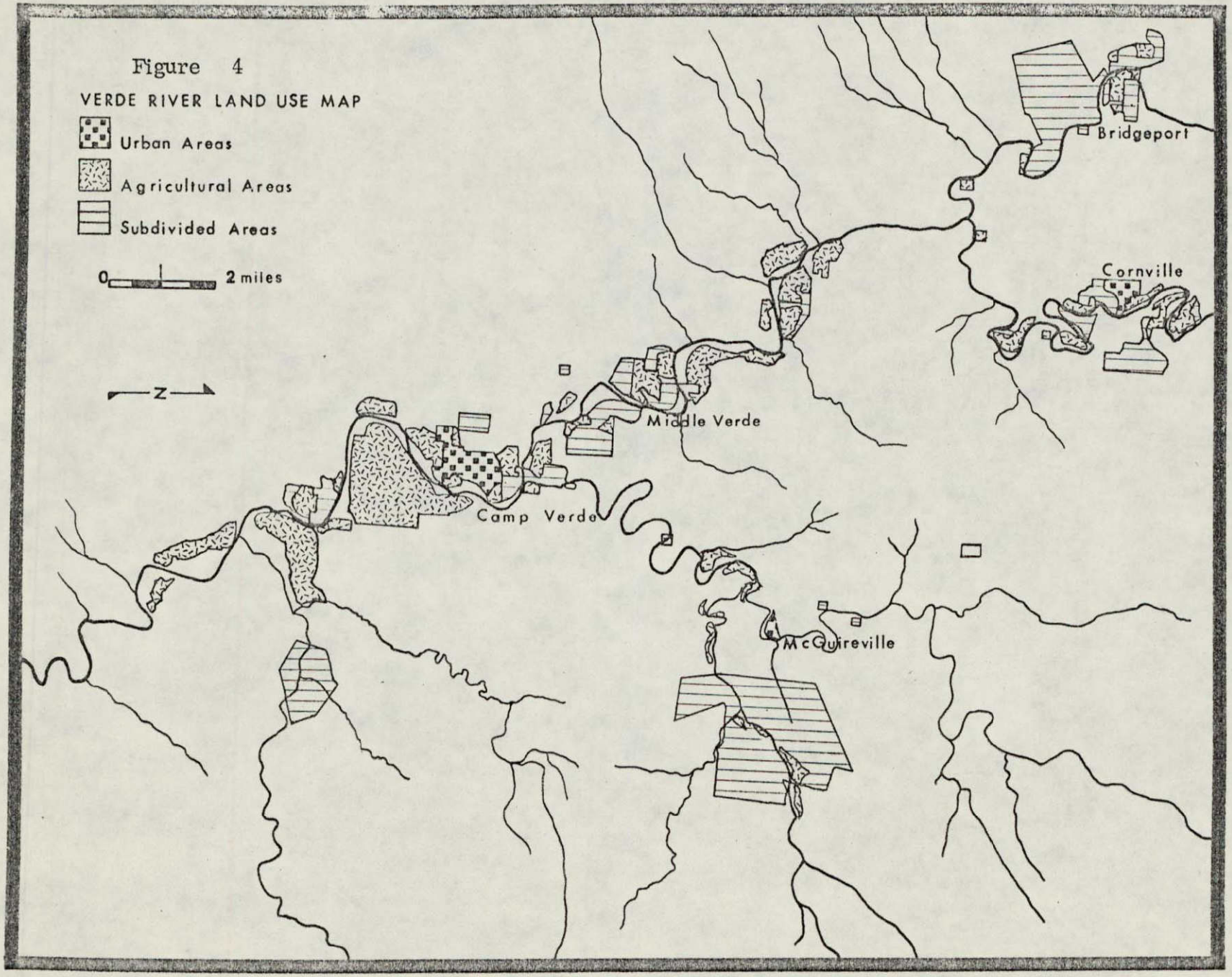


Figure 4
VERDE RIVER LAND USE MAP
Urban Areas
Agricultural Areas
Subdivided Areas
0
2 miles
N
Bridgeport
Cornville
Middle Verde
Camp Verde
McGuireville

Flood Hazard Map of the Verde River Interpreted from High Altitude Aircraft Photography, ERAP Mission 155, August 1971

Area of localized Flooding Along Channels

Area of Sheetflow Flooding and Accelerated Erosion

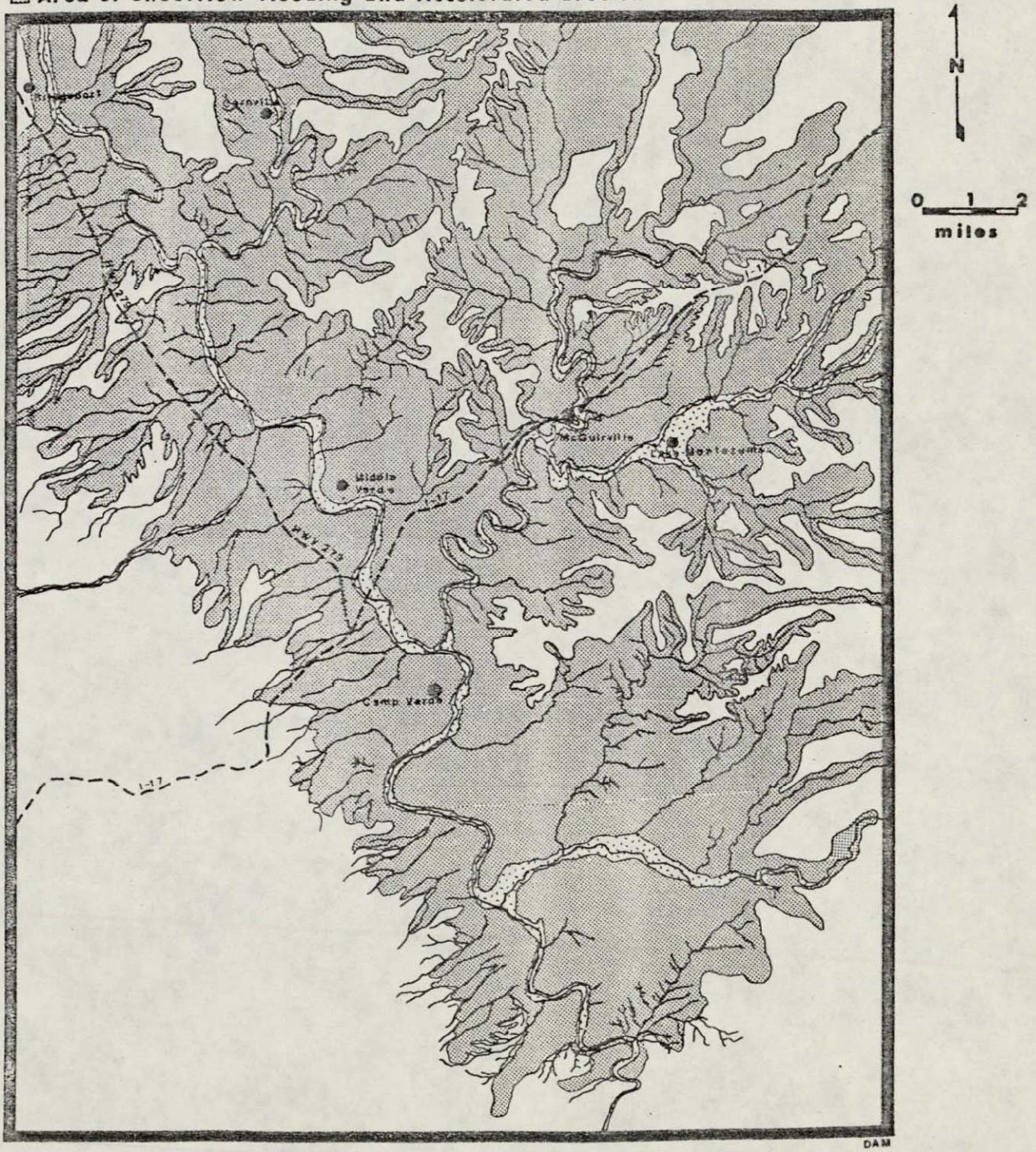


Figure 5. Verde River Flood Hazard Map

The larger scale and high resolution quanities of the imagery enabled the operator to make very accurate interpretations of flood hazard areas (Figure 6) and land use patterns (Figure 7). The same procedure was followed in delineating the floodplain and the land use in this area was used in the U-2 interpretations.

The results of this study are being used by the planning staff of Yavapai County to instate guidelines on what has been a situation of land use dominated by economic expediency. Remote sensing provided the basis for planning in a rapid growth area by virtue of a broad overview of land use interrelationships and a reasonable fast update capability. Land use data developed by this project has become a base from which county officials direct the growth of the area in such a way as to maximize the benefit derived from existing social services and utilities while avoiding potentially dangerous flood hazard areas and the excessive costs involved with development of such lands.

RESULTING USES

The interaction of the ARSP team with Graham, Yavapai and Yuma Counties represents a concentrated effort to work within the rural counties of Arizona. These counties share a common problem in that each is predominantly rural, but experiencing a rapidly expanding population. In each case the county has a planning directory who advises a Planning Commission and Board of Supervisors in their policy decisions regarding orderly, planned growth. For example, Yuma County in southwestern Arizona is one of the prime agricultural areas in the entire state. It borders on the Colorado River, and thus is also a prime area for new development of retirement communities and for weekend boaters interested in the area for water recreation. This situation is resulting in the removal of these agricultural lands from production and replacement with new subdivisions.

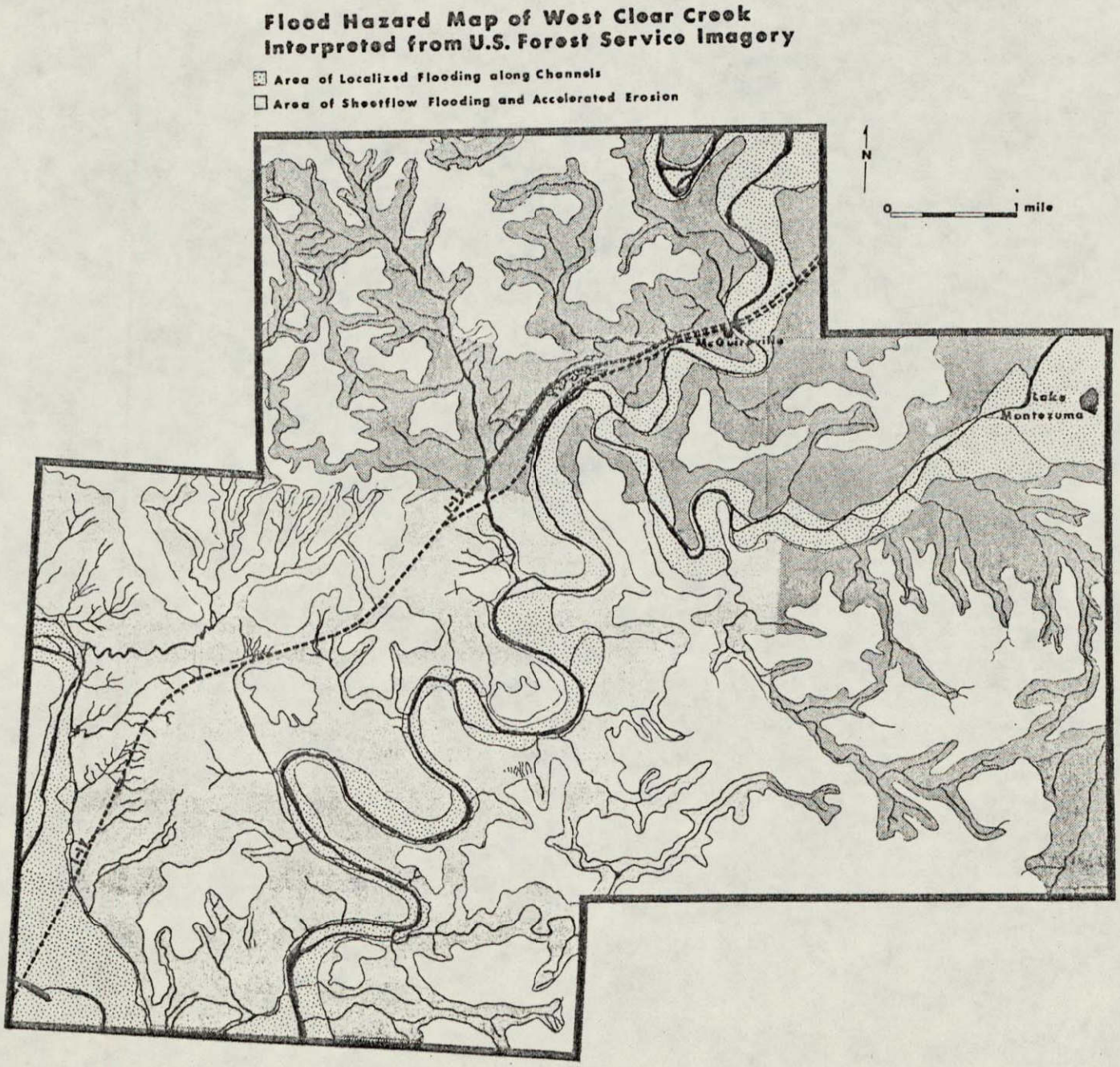


Figure 6. West Clear Creek Flood Hazard Map

Land Use Map of West Clear Creek Interpreted
from U.S. Forest Service Imagery

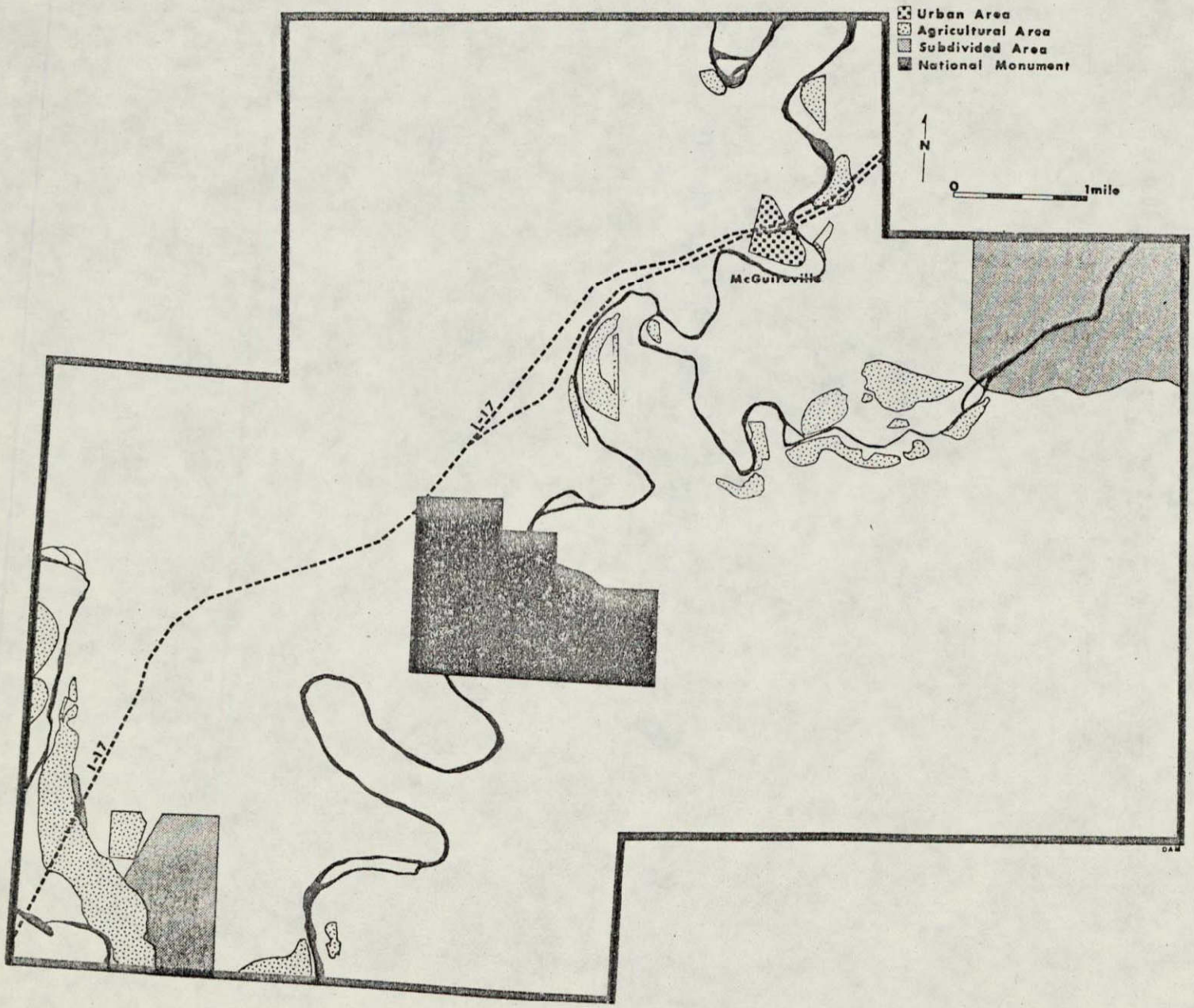


Figure 7. West Clear Creek Land Use Map

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The land use mapping and identification of flood hazard areas has allowed Yuma County to delineate agricultural areas that are not flood prone and possibly suited for development, while also enabling the county to enact legislation protecting the flood prone farming areas from development, and therefore maintaining high agricultural production.

To assist the Yuma County Planning Director in making day-to-day decisions, the remote sensing derived floodplain map was applied to orthophotoquads. The larger scale (1:24,000) of the orthophotoquads will enable to county planner to locate small areas of development. If this development falls within the floodplain, the developers will be required to elevate all construction above the computed 100-year flood level. Development adjacent to channels, in the so called floodway, will be prohibited. This area will be reserved for recreational activities only.

The Board of Supervisors has adopted a land use resolution that will protect all agricultural areas in the designated flood prone area of the lower Colorado and Gila Rivers. These areas will remain free from intense development and will be utilized for agriculture. Those agricultural areas lying outside the flood prone areas may opt for development if the owner desires.

Comprehensive, long-range plans are being developed in Yavapai county, which is experiencing rapid growth in remote areas. Yavapai County has had considerable growth along the Verde River and West Clear Creek drainages. In these areas, much of the higher land is dissected by minor channels on slopes too steep for concentrated development. Development has taken place in retired agricultural areas subject to periodic inundation. In many cases, lots are sold to persons from outside the Southwest who are unfamiliar

with the flooding potential of the ephemeral streams of arid and semiarid regions. Flood and erosion hazard maps on file at the office of the County Planning Department are allowing persons considering land purchase to examine their property in relation to these environmental hazards. The interpretations developed by ARSP for Yavapai County will also be acceptable to the Arizona Water Commission, for initial compliance with mandatory floodplain management regulations.

A problem common to all of the rural Arizona counties which have had interactive projects with ARSP is the subdivision of remote areas without application for planning department approval or submission of a plot. Such illegal subdivisions create a financial burden on county government, both in loss of potential fee and tax income and in the eventual costs of providing county services and enforcing land use laws after the fact. By use of remote sensing techniques, county planners have obtained timely and cost-effective information on the status of land within their areas. Current and accurate information on the status of subdivisions is essential to the county planning staff who are charged by the state government with the responsibility for rational planning decisions, but who have neither the personnel nor the funds for such activities.

Graham County, in southwestern Arizona, has a history of costly flooding in the area adjacent to the Gila River, between the towns of Solomon and Pima. The area shown in Figure 2, the town of Hollywiid, was severely flooded during a storm in November, 1972. The flood hazard map developed by ARSP for Graham County will be used to enforce laws directing new development away from areas subject to inundation. The need for such regulation in the project area is immediate due to increasing population pressure as a result of rapid expansion of mining in the area. As a result of the ARSP project the

exists now a data base for ordinances controlling further development of flood prone lands.

A small planning department is incapable of making the large-scale inventory that was made with the utilization of remote sensing. The projects, in which the ARSP has worked, signify the utilization of remote sensing at the truest grass roots level. The larger more densely populated counties, such as Maricopa and Pima in which Phoenix and the Tucson metropolitan areas are located, have the planning capability and staff necessary to carry out their own project. This is not the case with the counties in which the program has worked during 1975-1977. People who are serving on the Boards of Supervisors of these counties are predominantly ranchers, farmers and businessmen. Their exposure to advanced technology such as remote sensing and its applications to date has been minimal. The work done by the ARSP is a technology transfer process whereby the projects derived from remote sensing are utilized in a positive and meaningful way, in outlying areas to provide project information desperately needed by community leaders.